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Increase of Nitric Acid in the Lower Mesosphere During Solar Proton Events

P. T. Verronen

Finnish Meteorological Institute, Earth Observation, Helsinki, Finland

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The Team

P. T. Verronen, S.-M. Salmi, E. Kyrölä, J. Tamminen

Finnish Meteorological Institute, Earth Observation, Helsinki, Finland

M. L. Santee, S. Wang

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

C. J. Rodger

University of Otago, Department of Physics, Dunedin, New Zealand

M. A. Clilverd, A. Seppälä

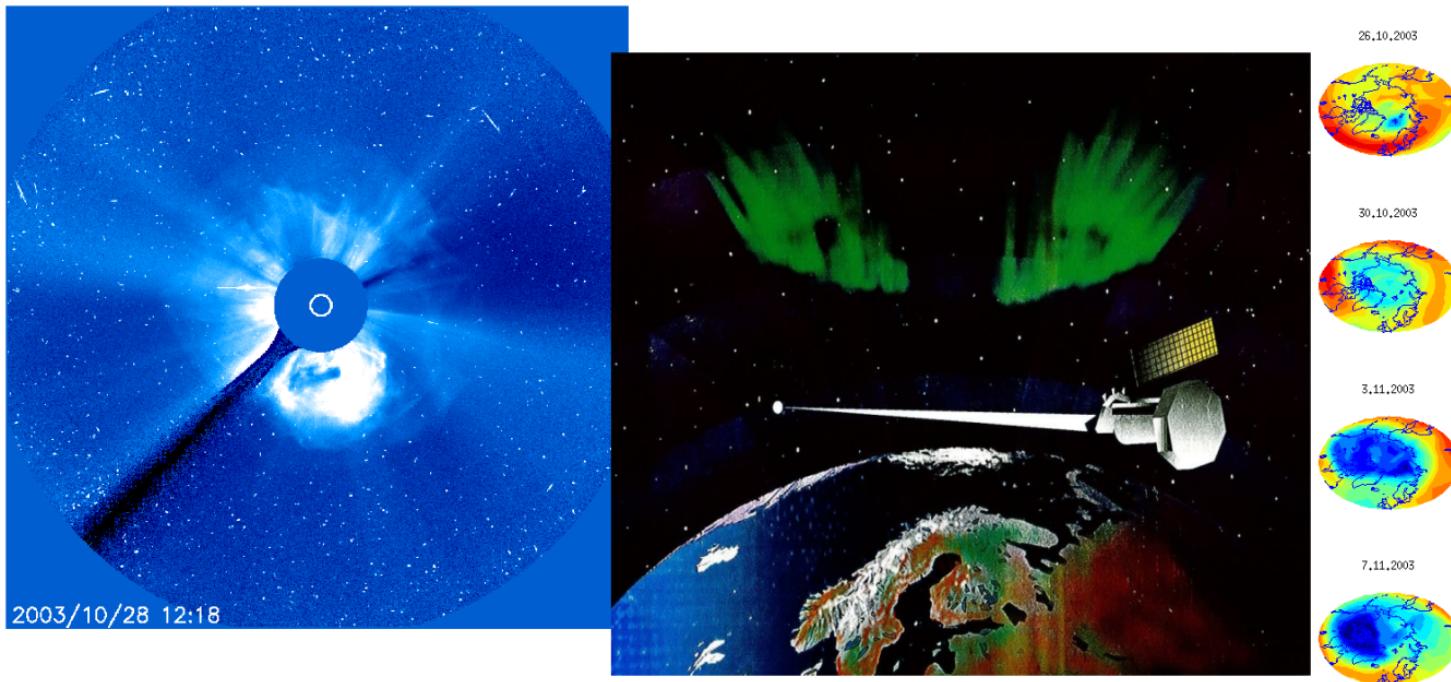
British Antarctic Survey (NERC), Cambridge, UK

E. Turunen

EISCAT Scientific Association, Kiruna, Sweden



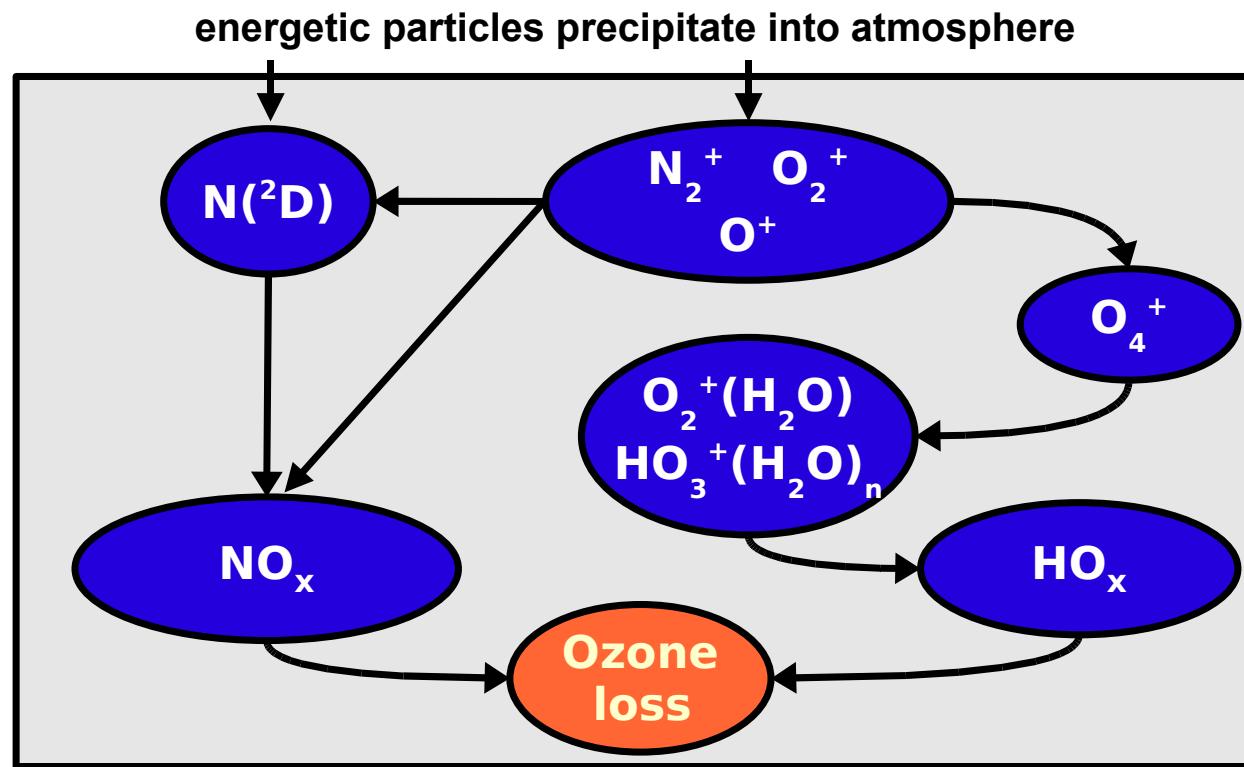
Solar proton event (SPE)



Earth's magnetic field directs charged particles into polar regions
EPP affects both ionosphere and middle atmosphere



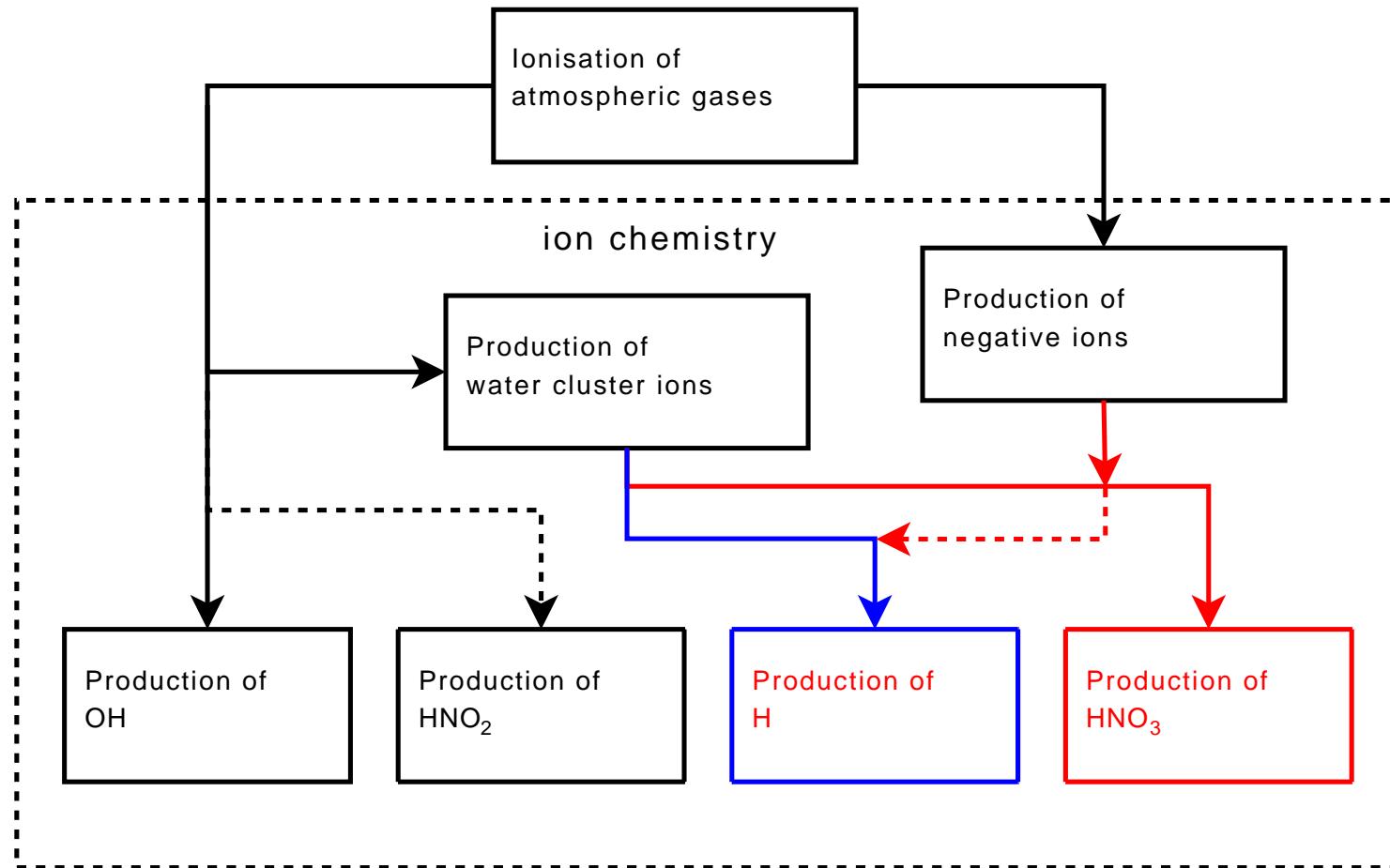
Atmospheric effects of EPP



Ozone connects to temperature and dynamics

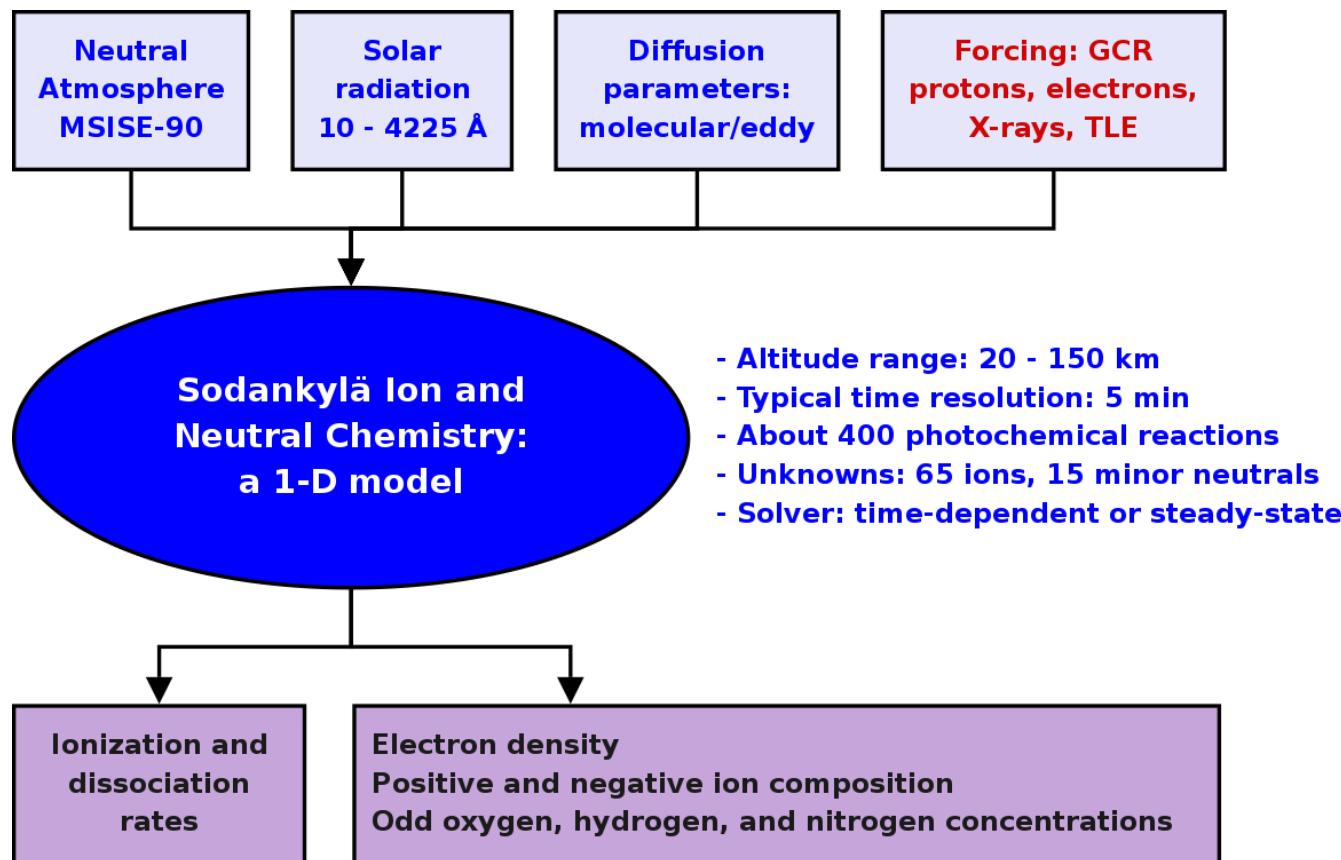


Production of nitric acid by ion chemistry





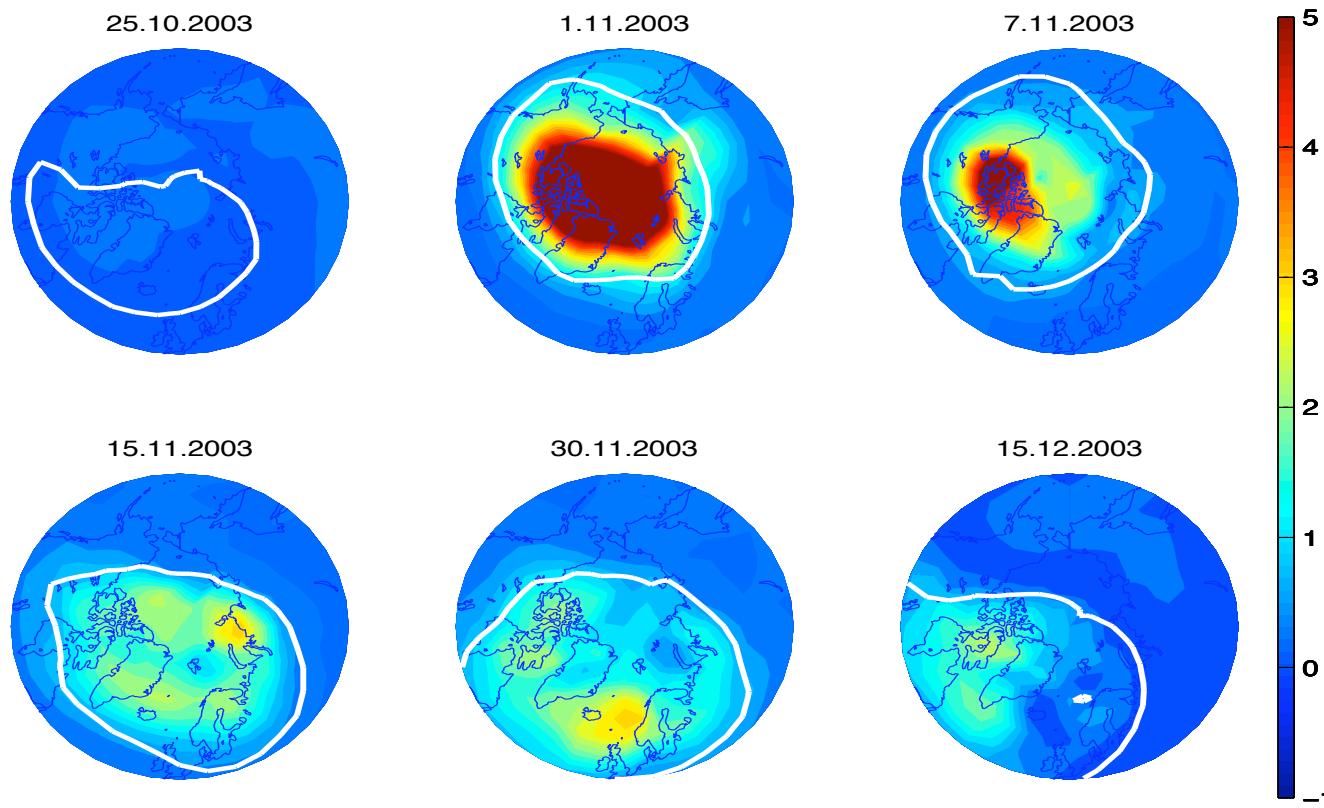
SIC model – Ion and neutral chemistry





Influence of polar vortex

HNO₃ (ppbv) at 45 km, Oct–Dec 2003



FinROSE chemistry-transport model



Nitric acid: comparisons

Modeling: Sodankylä Ion and Neutral Chemistry

- Uses MLS temperatures, neutral density, and water vapor.
- Dynamical effects cannot be considered.
- 80°N /December–January, no loss by photodissociation.
- All produced HNO_3 remains, the model gives an upper limit estimate.
- Revised reaction rate coefficients for ionic HNO_3 production.

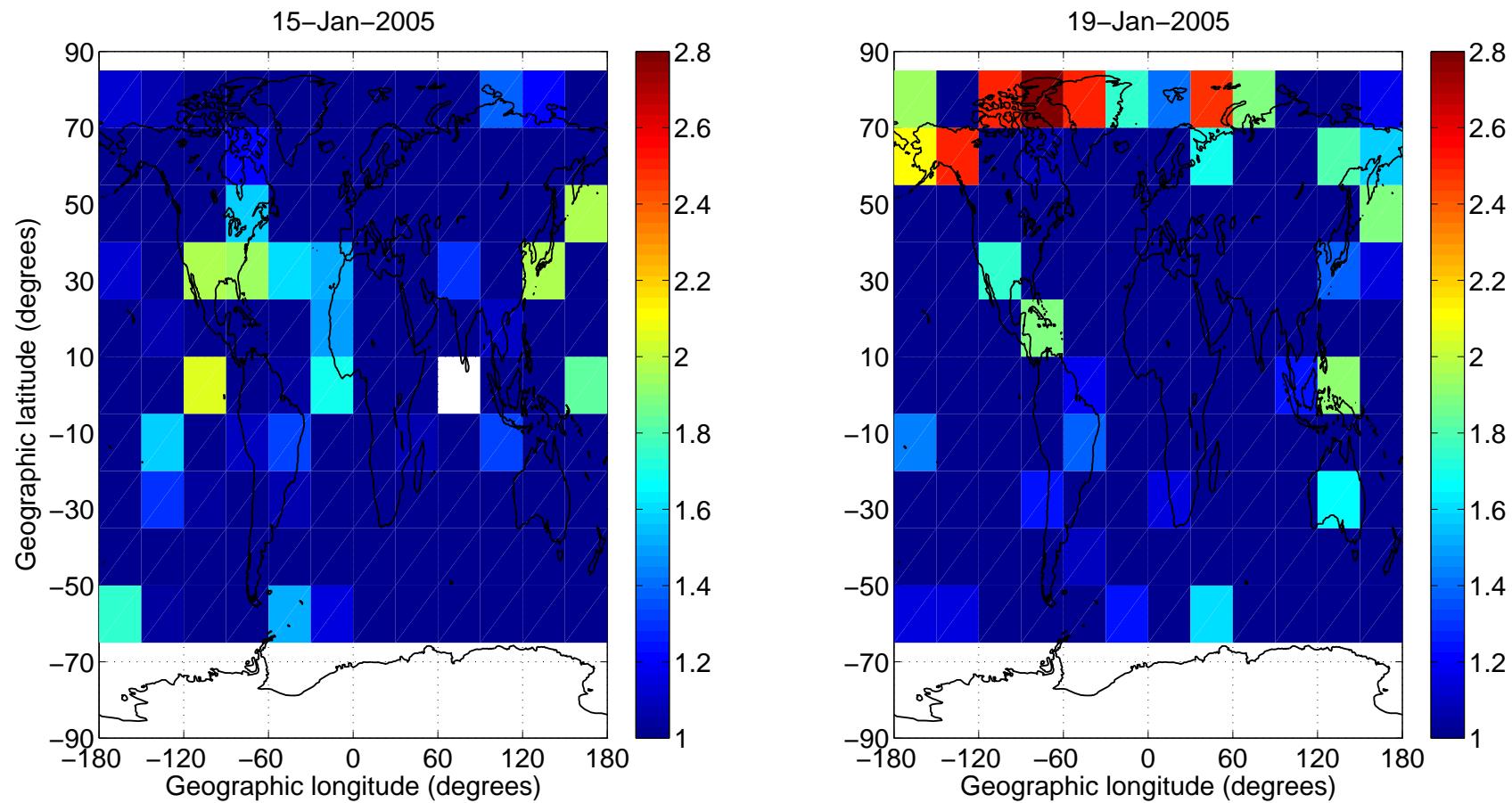
Observations: data version 2.2x, SZA $> 100^{\circ}$

- Useful range up to 3.2 hPa (≈ 40 km) in normal conditions, but can be extended into mesosphere when high amounts are observed.
- Mesospheric data have not been validated.
- Altitude resolution is worse than in the model, so model results have been converted to same resolution using averaging kernels.
- Comparison is made with the highest amount of HNO_3 observed after the peak of SPE forcing, assuming that it is least affected by dynamics/photodissociation.



Observations: increase of nitric acid at 50 – 60 km

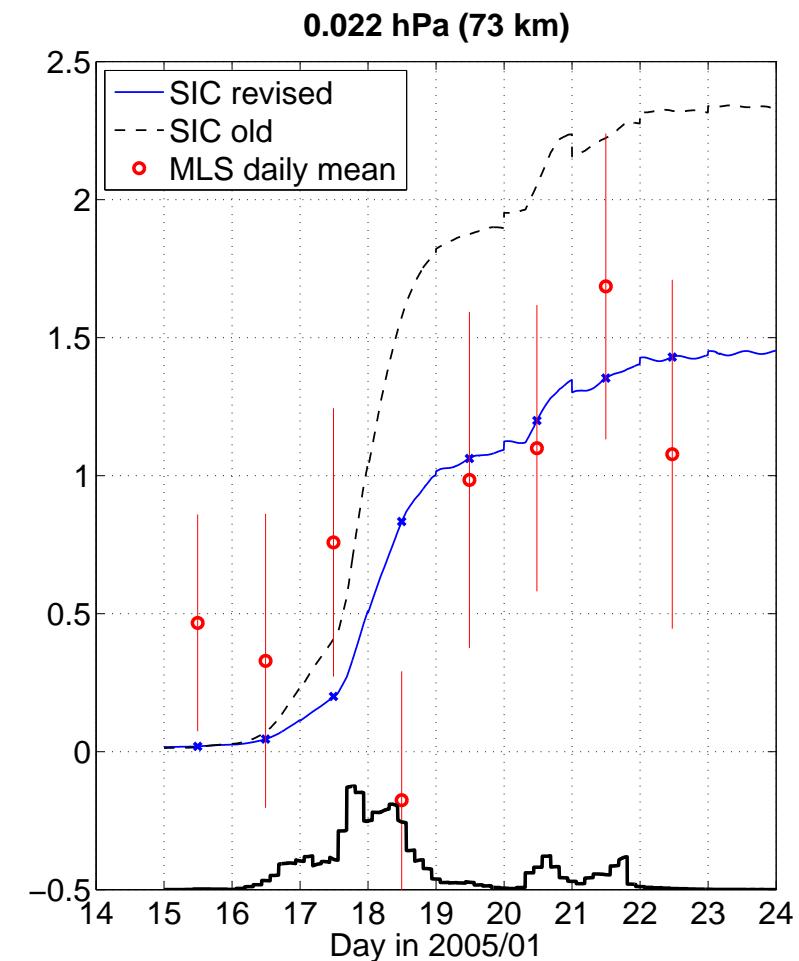
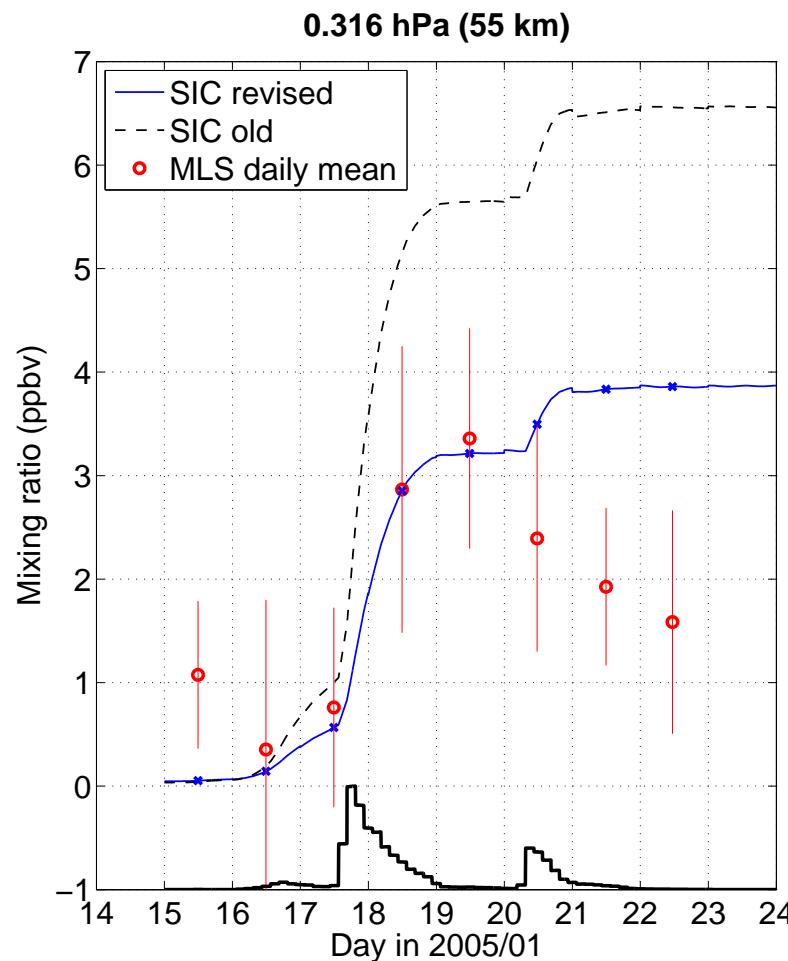
Solar proton event of January 2005





Comparison at selected altitudes

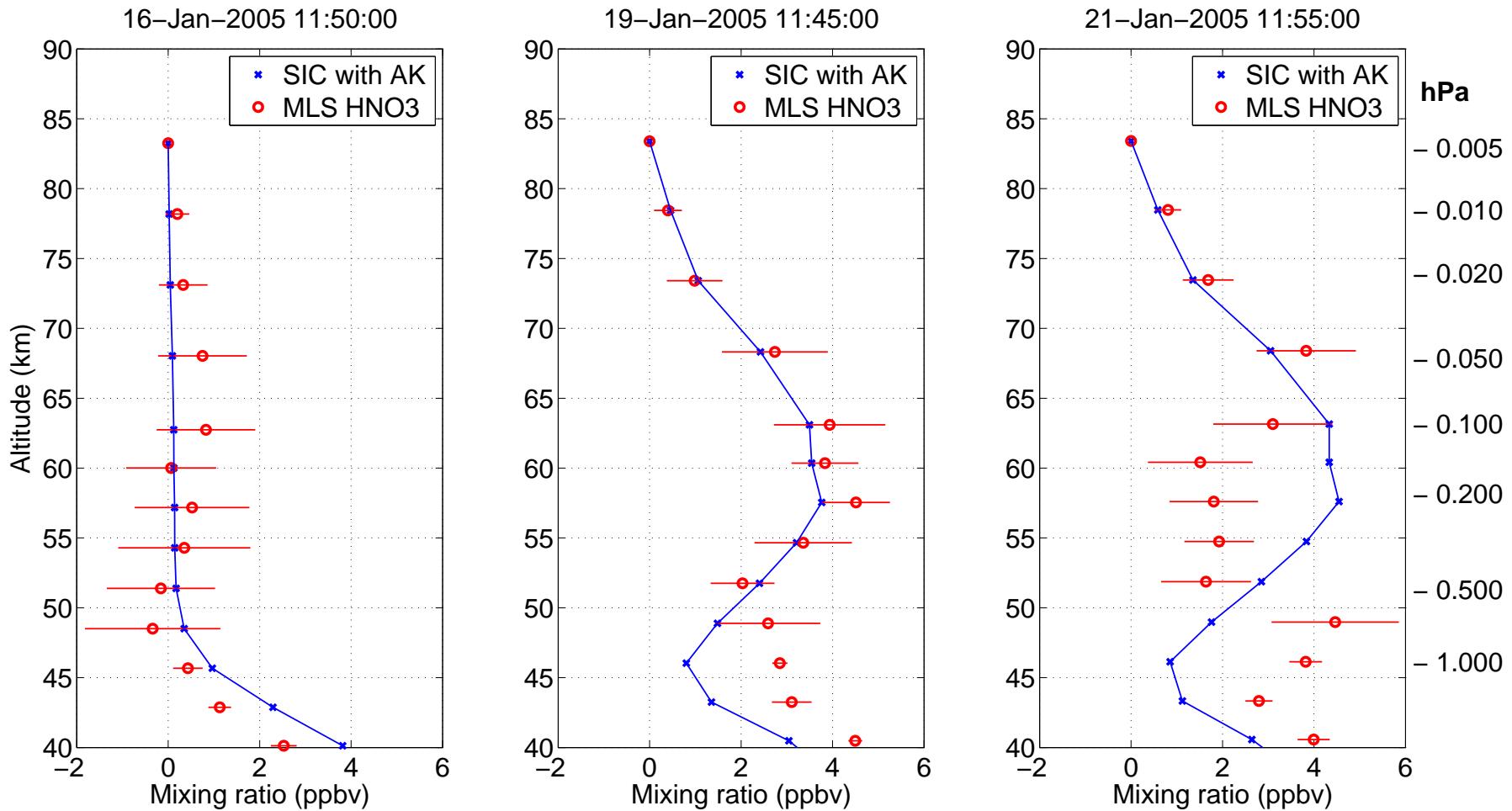
Solar proton event of January 2005





Comparison: before, during, and after SPE

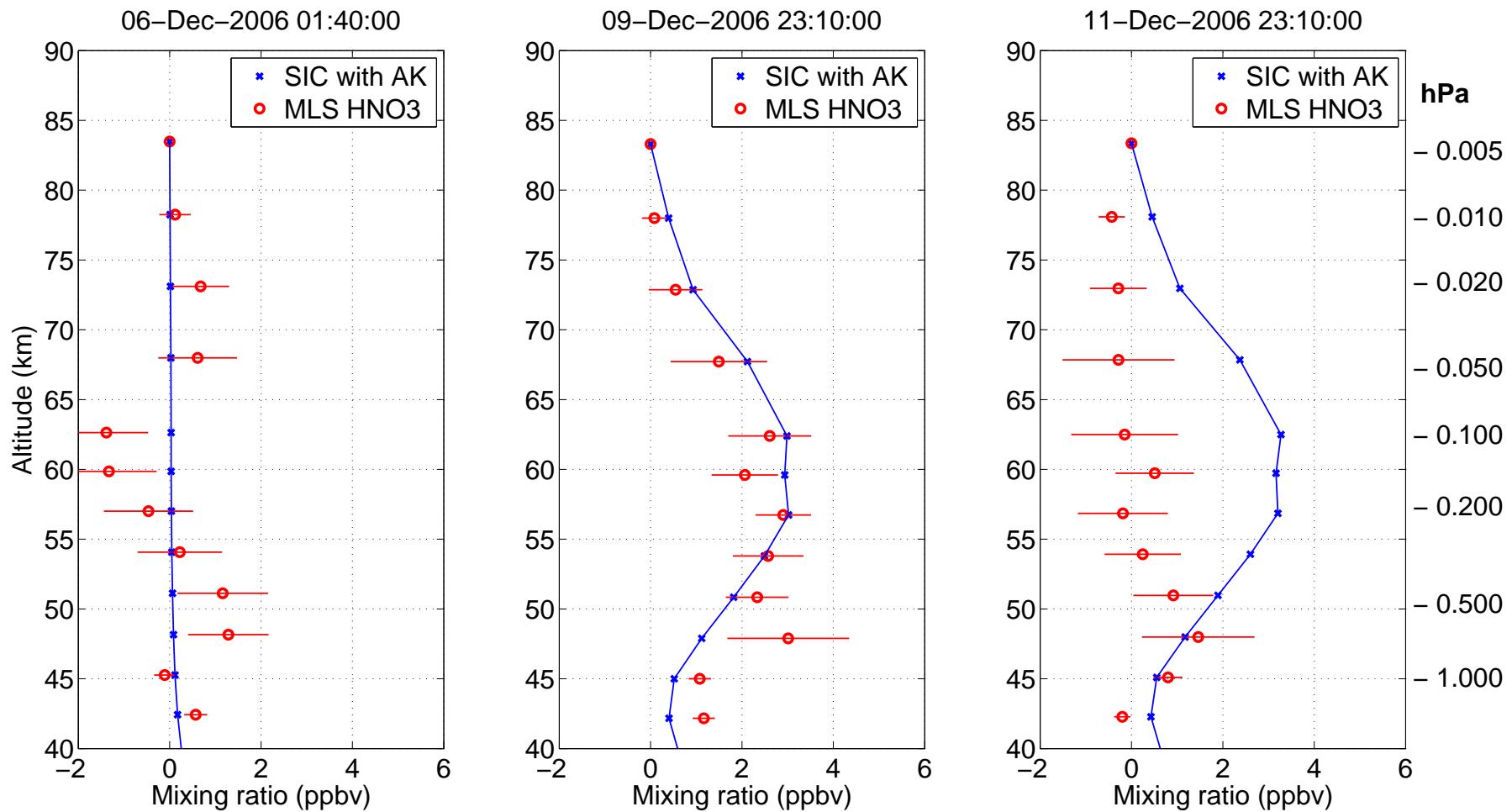
Solar proton event of January 2005





Comparison: before, during, and after SPE

Solar proton event of December 2006





Summary

- MLS/Aura observations show substantial increases of lower mesospheric HNO_3 during solar proton events.
- Ion and neutral chemistry modeling is in agreement with the largest mixing ratios observed.
- Comparisons with MLS data led to significant improvements in modeling.
- Quantitative understanding the SPE-related production of HNO_3 is challenging because of the dynamics.